REMARKS

Favorable consideration of this application is requested in view of the foregoing amendments and the following remarks.

The original independent claims have been modified to more clearly elucidate the properties, features, and advantages of the instant invention. Support for the new clarifying language in the claim amendments is found in the Specification.

Claims 1 and 11 are amended to include the limitations of claims 2 and 12, respectively. Claims 5, 7, 15 and 17 are rewritten in independent form. Claims 1, 5, 7 are amended to require an origin containing a center sphere that is characterized by zero power transmitted. Claims 11, 15 and 17 are amended to require an origin containing a center sphere that is used for counting purposes but not for energy determination. Support for claims 1 and 11 reciting wherein the three dimensional orthogonal symbol constellation includes an origin at {0,0,0} containing a center sphere characterized by zero power transmitted (claim 1), or used for counting purposes but not for energy determination (claim 11), is found at paragraph 0099, lines 11-13 and paragraph 0102, lines 5-6. Support for claims 5 and 15 reciting wherein the four-dimensional orthogonal symbol constellation includes an origin containing a center sphere characterized by zero power transmitted (claim 5), or used for counting purposes but not for energy determination (claim 15), is found at paragraph 0099, lines 11-13 and paragraph 0102, lines 5-6. Support for claims 7 and 17 reciting wherein the five-dimensional orthogonal symbol constellation includes an origin containing a center sphere characterized by zero power transmitted (claim 7), or used for counting purposes but not for energy determination (claim 17), is found at paragraph 0099, lines 11-13 and paragraph 0102, lines 5-6. Support for new claims

21-23 and 30-32 is found in paragraphs 0046, 0137 and 0138. Support for new claims 24-26 and 33-35 is found in paragraphs 0116, 0131 and 0132. Support for new claims 27-29 and 36-38 is found at paragraph 0080, lines 5-7. Support for new claims 39-42 is found in original claims 10 and 20. Support for new claims 43-44 is found in paragraph 0106.

At page 2 of the Office Action dated February 21, 2007 the examiner objects to the specification. The specification is amended to recite Ser. No. 10/726,475.

Accordingly, withdrawal of this objection is respectfully requested.

At page 2 of the Office Action, the examiner objects to the claim numbering. The claim numbering is corrected in this amendment. The examiner objects to the recitation of "carrier signal" in claims 1-10. The term carrier is deleted from the claims.

Accordingly, withdrawal of this objection is respectfully requested.

Claims 1-20 were rejected under 35 USC 101. Claims 1-10 are amended to require transmitting the signal. Similarly, claims 11-10 are amended to require receiving the signal.

Accordingly, withdrawal of this rejection is respectfully requested.

Claims 1 and 11 stand rejected as being anticipated by Welti (U.S. Patent 4,084,137).

Claims 1 and 11 are now amended to include the limitations of claims 2 and 12 and all the independent claims now exclude the (hyper)sphere at the origin as zero power transmitted (claims 1, 5 and 7) or used for counting purposes but not for energy determination (claims 11, 15, 17).

Welti discloses methods and systems for communications using multi-dimensional coding techniques. These include the use of amplitude, phase (differential), time (e.g., QAM), and polarization modulation. The heart of Welti is the use of specific "compact" codes derived from standard error-code analysis methods (i.e., Hamming) to obtain robust transmission codes

by choosing neighboring codes with exactly two differing components. Welti also discloses digital means (ROMs, mappers, and D/A converters) of generating and receiving the described coded signals. His codes are strictly based on Cartesian coordinate mappings of code constellation points [see his Specification, column 3, lines 36-68 and column 4, lines 1-27].

However, Welti does not disclose or suggest the concept closely packed (hyper)spheres to drive multi-dimensional signal constellations and Welti does not disclose or suggest excluding the origin (zero-signal) point in the constellation. Very significantly, Welti also explicitly teaches away from the concept of excluding the origin (zero-signal) point in the constellation [see his column 4, lines 29-35], in which he explicitly teaches ***"Note that the code constellation for M=8 is identical to a four-phase PSK constellation. This is also true of the M=17 constellation if the point at the origin is ignored; however, to do so eliminates the interdependence of codeword components which is an important feature of the codes employed by the communication systems according to the invention."*** (emphasis added) This is diametrically opposite to the claimed invention, which now explicitly ***excludes*** the origin point in all the independent claims.

The specific exclusion of the (hyper)sphere at the origin in the constellation permits a definitive, intrinsic detection of the zero-signal state in the receiver; this feature obviates the need for separate signal-strength detection circuitry in the receiver to properly account for the no-signal condition (i.e., when there is no valid incoming signal). This is a distinct advantage over prior-art systems which inevitably require additional circuitry (e.g., "squelch" or carrier-detect) to sense this realistic but non-data state.

With regard to new claims 21-23 and 30-32, the DSQAM idea [paragraphs 0137-0142] is a completely new concept in modulation. The DSQAM idea combines standard QAM

techniques with direct-sequence codes. In essence, the DS code is assigned to a state of the modulation constellation ***and not to a bit state (0 or 1) as is usually done***. Standard CDMA communications can be enhanced by this reinterpretation. Each user would have several DS codes, defining a constellation unique to that user. None of the references cited by the Examiner even mention such a concept, much less employ it as a dimensional (single or multiple) modulation technique as in the present case. The use of PN spreading codes as a separate data-modulation constellation dimension, as illustrated herein, is novel and nonobvious over the prior art.

With regard to new claims 24-26 and 33-35, the signal constellations are optimally packed in a multi-dimensional sense, and the resulting average signal-to-noise ratio required for a given bit- or symbol-error rate in Gaussian (white) noise is minimized. The optimum constellation can be associated with the distinction between the hypercube *exactly enclosing* the constellation and the hypersphere merely *bounding* the constellation.

With regard to new claims 27-29 and 36-38, the result is a 3- to 5-dimensional signal structure which is *not only* mathematically orthogonal in each signal-modulation dimension, *but also* maximally information-dense. This can be associated with the distinction between the hypercube *exactly enclosing* the constellation and the hypersphere merely *bounding* the constellation.

Accordingly, withdrawal of this rejection is respectfully requested.

Claims 2 and 12 stand rejected as being unpatentable over Welti (U.S. 4,084,137) in view of Biglieri (*Digital Modulation Techniques*, CRC Press, 2002). The limitations of claims 2 and 12 are now recited in claims 1 and 11 and the following response directed to the examiner's combination of Welti and Biglieri.

Welti does not disclose or suggest the concept of closely packed (hyper)spheres to drive multi-dimensional signal constellations and Welti does not disclose or suggest excluding the origin (zero-signal) point in the constellation. Further, as noted above, Welti teaches away from the concept of excluding the origin point, whereas such is essential to the instant invention.

Biglieri does not obviate the deficiencies of Welti. Biglieri, as a brief, high-level survey of the material [his Chapter 20.6, as cited by the Examiner] *mentions* lattices and higher dimensional (>2) constellations but utterly fails to disclose the actual constellations resulting from such mathematical exercises. More significantly, Biglieri does not teach or even allude to the detailed procedures of computing the higher-dimensional symbol-error rates via the multi-dimensional integrals and approximation techniques disclosed in the instant case [our paragraphs 0117-0123 and FIGS. 10-15]. The specific form of the integral approximation employed in the instant case is described in detail in paragraph 0117 and given explicitly in Equation 30 of the Specification:

$$\mathcal{A}_{\mathrm{hull}} = (2\pi\varepsilon^2)^{-n/2}\left(\int_{-\delta/2}^{\delta/2} e^{-\frac{\xi^2}{2\varepsilon^2}}\, d\xi\right)^n = \operatorname{erf}\left(\frac{\delta}{2\sqrt{2}\,\varepsilon}\right)^n. \qquad (30)$$

As cited in the last sentence of paragraph 0117, the symbol-error rate (SER) for a data receiver according to our invention is equal to one minus the aforementioned integral.

Further, all the references fail to disclose the fact that the mathematical solutions for higher-dimensional geometric centers, in general theoretical lattices, are not the same as optimum constellations for actual physical communications systems. The optimal criterion in the case of probability distributions for practical communications is somewhat different since the

theoretical packing problem refers to a space-filling solution, whereas real signals have finite power and do not fill all space. Specifically, what the invention provides is a solution on the surface of the sphere with radius equal to the square root of the power in the signal. The invention provides solutions to the following two questions. How many centers can be distributed on the surface of a sphere in two, three, or four dimensions such that the minimum distance between centers is a constant? How are spheres of different radii (power) to be packed, one inside another? This is a sphere-packing problem on a *sphere*, <u>not in unlimited space</u>. This problem has been practically solved in the instant application through the use of numerical approximation techniques [see paragraphs 0117-0123 and FIGS. 12-15], though ***no*** pure mathematical solutions for the higher dimensional cases (i.e., >3D) have yet been offered in the known open literature or patents.

Accordingly, withdrawal of this rejection is respectfully requested.

Claims 3, 4, 13, 14, and 16 stand rejected under 35 USC § 103(a) as being unpatentable over Welti in view of Shattil (U.S. Patent 6,686,879).

As noted above, Welti <u>does not disclose or suggest</u> <u>the concept of closely packed (hyper)spheres</u> to drive multi-dimensional signal constellations and Welti does not disclose or suggest <u>excluding</u> the origin (zero-signal) point in the constellation. Again, as noted above, Welti <u>teaches away</u> from the concept of excluding the origin point, whereas such is essential to the instant invention.

Shattil discloses multiple basic modulation methods (e.g., phase, amplitude, frequency, time-offset, polarization, and combinations thereof) [his paragraph 14, lines 35-40] and well known demodulation methods (e.g., filtering, envelope detection, sampling, under-sampling, time-offset sampling, frequency-offset sampling, etc.) [his paragraph 12, lines 59-67].

However, Shattil in his development of his "carrier-interferometry" transmission and reception methods and systems, completely fails to disclose or suggest the claimed invention. This includes the close packed hypersphere-based constellations and the exclusion of the zero-energy hypersphere at the origin.

Accordingly, withdrawal of this rejection is respectfully requested.

Claims 5, 7, 15, and 17 stand rejected under 35 USC § 103(a) as being unpatentable over Welti (U.S. 4,084,137) in view of Biglieri (Digital Modulation Techniques, CRC Press, 2002).

As noted above, Welti <u>does not disclose or suggest</u> <u>the concept closely packed hyperspheres</u> to drive multi-dimensional signal constellations and Welti does not disclose or suggest <u>excluding</u> the origin (zero-signal) point in the constellation. Further, as noted above, Welti <u>teaches away</u> from the concept of excluding the origin point, whereas such is essential to the instant invention.

As noted above, Biglieri does not obviate these deficiencies of Welti. Biglieri, as a brief, high-level survey of the material [his Chapter 20.6, as cited by the Examiner] mentions lattices and higher dimensional (>2) constellations but utterly fails to disclose the actual constellations resulting from such mathematical exercises. Biglieri does not expressly teach the specific [four-dimensional] constellation" [of hyperspheres with 24 nearest neighbors, excluding the point at the origin]. More significantly, Biglieri does not teach or even allude to the detailed procedures of computing the higher-dimensional symbol-error rates via the multi-dimensional integrals and approximation techniques disclosed in the instant case [our paragraphs 0117-0123 and FIGS. 10-15]. Neither does Biglieri address at all the exclusion of the zero-energy hypersphere at the origin. Thus again, Biglieri in no way obviates the deficiencies of Welti. In light of the above

arguments and the present amendments to the claims, these rejections are likewise rendered moot. The claims cited above as presently amended thus should be allowable.

With regard to claims 5, 15, 22, 25, 28, 31, 34, 37, 39, 41 and 43-44, it was described in this application as originally filed that a 4D-FCC (face-centered cubic) lattice was optimal in the sense that it allows efficient packing of spheres (regions for identifying symbols). Higher dimensional spaces have more places to put these symbol points, but they are less efficient in that spheres of larger size (higher noise) can be placed between the lattice spheres. This means more signal power must be used to cover the selected lattice points; this thus wastes signal power. In lower-dimensional spaces, the converse is true. The spaces between the lattice spheres are too small to accommodate an additional lattice sphere. It was noted in this application as filed that 4 physical aspects of an electromagnetic wave exist that correspond to 4 dimensions (frequency, phase, amplitude, polarization). Going to a fifth dimension is possible but not particularly advantageous from an optimal power standpoint. The claimed signal space does not need to exhaust this list of physical features but can be easily adapted to comply with system hardware requirements. Combining the two concepts of the physical aspects of electromagnetic waves and the packing properties of spheres in higher dimensions and restricting them to an optimum 4D signaling space is highly nonobvious as it requires analysis of the geometric properties of the 4D space and the physical properties of an electromagnetic wave done simultaneously in the same thought process.

With regard to claims 43 and 44, another point of nonobvious novelty in the instant case is the extension of the Stokes parameters and the Poincaré sphere to 4 dimensions. The practical meaning is that the claimed invention can include a modulation and demodulation methodology based on a 4D Poincaré sphere that retains the advantages of the 4D space and

its FCC packing while dealing only with phase and polarization. The resulting apparatus is then simpler than corresponding prior-art units in that it does not need to consider frequency or amplitude as variables. This can result in considerable cost, power, and complexity advantages in a 4D receiver implementation.

With regard to claims 25, 28 34 and 37, the lattice signal-state spheres match the size of the in-between spheres, which then are subsumed into the lattice. This combination of the packing fraction and kissing number are optimal in 4D to create the noted efficiency. This has not been noticed by anyone before, nor was it even alluded to in the references cited by the Examiner in the Office Action of 2/21/2007.

Accordingly, withdrawal of this rejection is respectfully requested.

Claims 8, 9, 18, and 19 stand rejected under 35 USC § 103(a) as being unpatentable over Welti (U.S. Patent 4,084,137).

Again, Welti does not disclose or suggest the concept closely packed hyperspheres to drive multi-dimensional signal constellations and Welti does not disclose or suggest excluding the origin (zero-signal) point in the constellation. As noted above, Welti teaches away from the concept of excluding the origin point, whereas such is essential to the instant invention.

Accordingly, withdrawal of this rejection is respectfully requested.

Claims 3 and 14 stand rejected under 35 USC § 103(a) as being unpatentable over Welti in view of Klymyshyn, et al. (U.S. Patent 5,825,257).

Once again, Welti does not disclose or suggest the concept closely packed (hyper)spheres to drive multi-dimensional signal constellations and Welti does not disclose or suggest excluding the origin (zero-signal) point in the constellation. Once again, Welti teaches

away from the concept of excluding the origin point, whereas such is essential to the instant invention.

Klymyshyn, et al. (hereinafter, Klymyshyn) does not obviate these deficiencies of Welti. Klymyshyn discloses techniques for generating a Gaussian minimum-shift keying (GMSK) signal, which is a spectrally efficient, constant-envelope signal. Because Klymyshyn simply discloses a GMSK modulator capable of direct microwave-frequency carrier modulation of MSK with a continuous-phase digitally synthesized analog modulator with a phase-locked loop controller (preceded by a Gaussian modulation-shaping filter), it is clear that Klymyshyn does not obviate the aforementioned deficiencies of Welti.

Accordingly, withdrawal of this rejection is respectfully requested.

Other than as explicitly set forth above, this reply does not include acquiescence to statements in the Office Action. In view of the above, all the claims are considered patentable and allowance of all the claims is respectfully requested. The Examiner is invited to telephone the undersigned (at direct line 928-226-1073) for prompt action in the event any issues remain that prevent the allowance of any pending claims.

In accordance with 37 CFR 1.136(a) pertaining to patent application processing fees, Applicant requests an extension of time from May 21, 2007 to August 21, 2007 in which to respond to the Office Action dated February 21, 2007. A notification of extension of time is filed herewith.

The Director of the U.S. Patent and Trademark Office is hereby authorized to charge any fees or credit any overpayments to Deposit Account No. 50-3204 of John Bruckner PC.

Respectfully submitted,

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Dated: Aug 21, '07

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